# Ozark Plateau

## 2010 Field Analysis Summary

May 20, 2011

Basin Management Team

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# I. Introduction

The Ozark Plateau is a four-state region located primarily in southern Missouri and northern Arkansas, and includes smaller areas in northwest Oklahoma and southeast Kansas (Figure 1). The Ozark Plateau consists of four physiographic regions: the Springfield Plateau, Salem Plateau, Saint Francois Mountains and Boston Mountains. Of these four regions only a small portion of the Springfield Plateau extends into the far southeastern corner of Kansas. Under this corner of Kansas lies the Ozark Plateau aquifer.

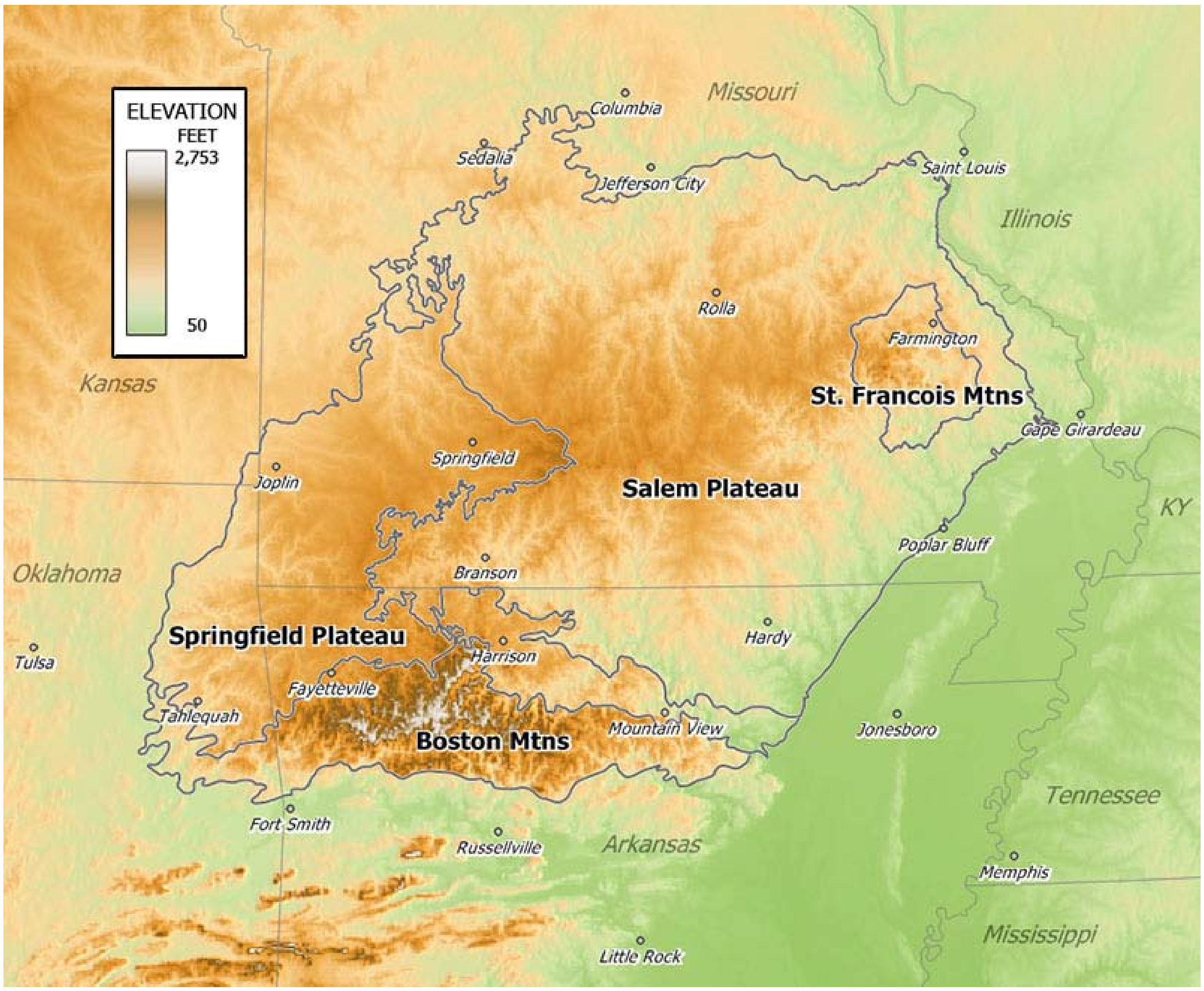


**Figure 1: Ozark Plateau**
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The Ozark Plateau aquifer is an important source of water for the quad-state region of southeast Kansas, southwest Missouri, northeastern Oklahoma and a small portion of northwest Arkansas. The Ozark Plateau aquifer consists of two aquifers separated by a discontinuous confining unit. The upper, shallower aquifer is the Springfield Plateau aquifer; the lower, deeper aquifer is the Ozark aquifer (Figure 2).

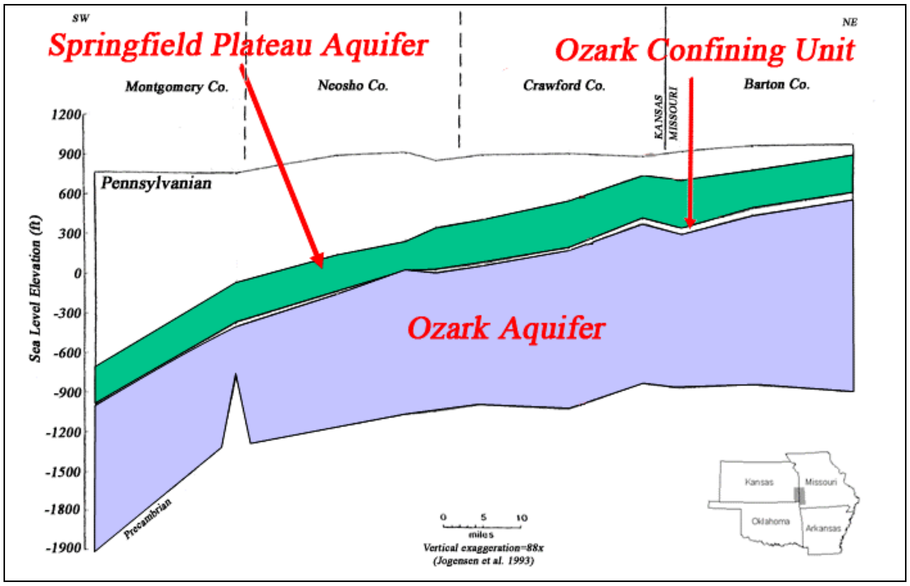


**Figure 2: Ozark and Springfield Plateau Aquifer**

Figure taken from Kansas Geological Survey Open File Report 2007-20 *The Southeast Kansas Ozark Aquifer Water Supply Program*.

The Springfield Plateau aquifer contains fresh water in southwest Missouri and northeast Oklahoma, where it is shallow and can produce water sufficient for domestic purposes. However, water quality of the Springfield Plateau aquifer in Kansas is poor and may be unfit for domestic use due to the prior extensive lead and ore mining in the area. Mining shafts have allowed contaminated water to move from the surface into the aquifer.

The Ozark aquifer contains usable water in southeast Kansas and is the source for most of the groundwater supplied to area municipalities and rural water districts. At the bottom of the Ozark aquifer is a brine layer (salt water) that is moving west to east across Kansas. There has been concern that significant groundwater pumping in areas could potentially cause upwelling of brines within the aquifer and adversely impact water quality.

In 2004, the Kansas Department of Agriculture's Division of Water Resources (KDA-DWR) established a moratorium on new appropriations from the aquifer in Kansas, except for some specified exceptions, due to uncertainty at that time about the available water supply in the Ozark aquifer, and potential water quality concerns. The moratorium referenced a study of the Springfield Plateau aquifer and Ozark aquifer that was to be completed by December 31, 2010 (K.A.R. 5-3-29). (http://ks.water.usgs.gov/Kansas/studies/OzarkAquifer/index.html).

The study by the U.S. Geological Survey (USGS), with state and local involvement, was actually completed in August 2009. A decision was made by Chief Engineer David Barfield in December 2010 to lift the moratorium and reopen the area to new appropriations. Regulation addressing safe yield for these aquifers is under development.

A groundwater well monitoring network was re-established in 2004 for the former Ozark aquifer moratorium area. The network consists of 27 wells. Of these 27, there are 24 that are screened within the Ozark aquifer or both aquifers (referred to as the Ozark Plateau aquifer), and are measured on a quarterly basis. The remaining three wells were drilled in 2006 and are dedicated observation wells. Two of these dedicated observation wells monitor the Ozark aquifer, one at McCune and one at Pittsburg, while the last well, also located at Pittsburg, monitors the Springfield aquifer. All three wells are equipped with transducers for continuous data collection but since January 2011 these wells no longer have telemetry (satellite) equipment installed, which permitted real time data access. Data is still collected and stored on a daily basis, however access to this data is now limited to onsite and will be manually downloaded while measuring the quarterly groundwater well monitoring network. In addition, in order to detect the potential eastward movement of salt water, a network consisting of 12 wells has been established within the existing network from which water quality samples are taken quarterly.

# II. Precipitation

Precipitation in the Ozark Plateau area in Kansas historically averages 41.5 inches per year based on six precipitation stations. Figure 3 shows the annual variation in precipitation and the long term average precipitation. This chart was derived from National Climatic Data Center (NCDC) stations located in Columbus (Cherokee County), Erie (Neosho County), Fort Scott (Bourbon County), Moran (Allen County), Parsons (Labette County) and Pittsburg (Crawford County). The data is downloaded then averaged to create the following chart.

The highest precipitation total occurred in 1985 with 59 inches. The lowest precipitation occurred in 1963 with 22 inches. In 2009, the precipitation total based on the average of Fort Scott and Pittsburg stations was 58 inches. It is important to note that in 2009, three of the precipitation stations contained incomplete data sets and were not used in the annual statistics calculation. In addition, the Moran station in Allen County was discontinued in 2009. Annual precipitation data for these NCDC stations is currently available through 2009.

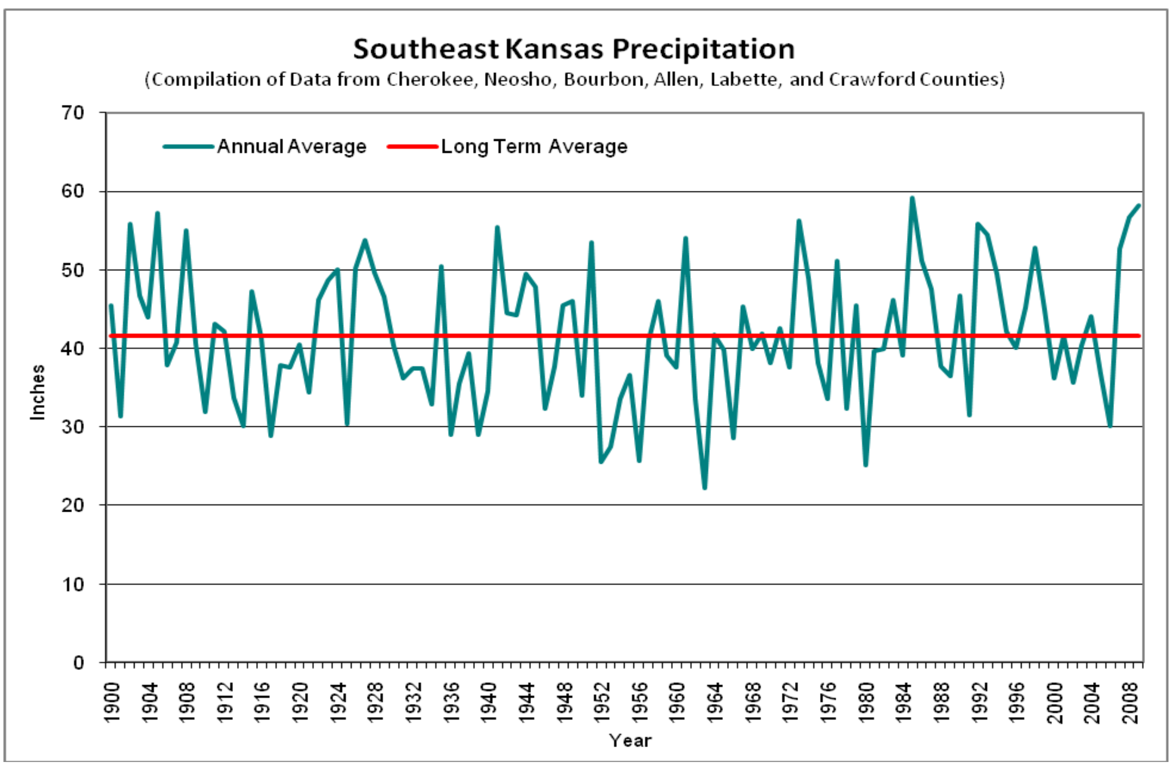


**Figure 3: Average Ozark Precipitation 1900-2009**

Figure 4 shows the preliminary monthly precipitation for 2010 and the long term monthly average. With these measurements, the subbasin experienced an average of 41.7 inches in 2010. September had the highest average with 9 inches while December had the lowest precipitation average with 0.9 inches.

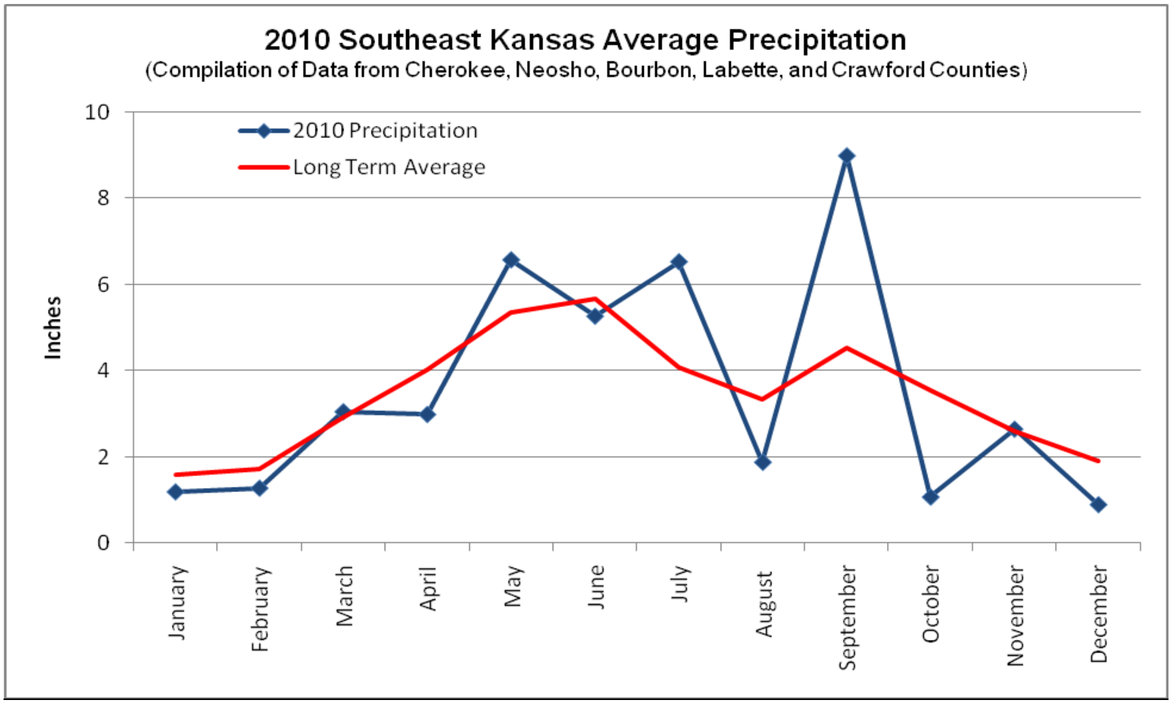


**Figure 4: 2010 Average Monthly Precipitation**

# III. Surface Water

The Neosho River and the Spring River are the two major river systems that cut through the former moratorium area boundary of the Ozark Plateau aquifer (Figure 5). The lower Neosho River flows through Neosho and Labette counties, and briefly flows through the southwest corner of Cherokee County before flowing out of Kansas into Oklahoma. The Spring River enters Kansas from Missouri on the eastern side of Cherokee County, flows through Cherokee County, and exits the state at the southern part of the county into Oklahoma.

Both river systems are monitored by the USGS and have streamflow gages positioned near Parsons, Kansas on the lower Neosho River and near Baxter Springs, Kansas and Quapaw, Oklahoma on the Spring River (Figure 5). In addition, the USGS Spring River gage near Waco, Missouri is shown, as well as the USGS Shoal Creek gage near Joplin, MO (Figure 5). These gages measure flow entering Kansas since the water systems flow East over the state line from Missouri. Shoal Creek is the tributary to the Spring River, meeting it at the Empire District Lake.

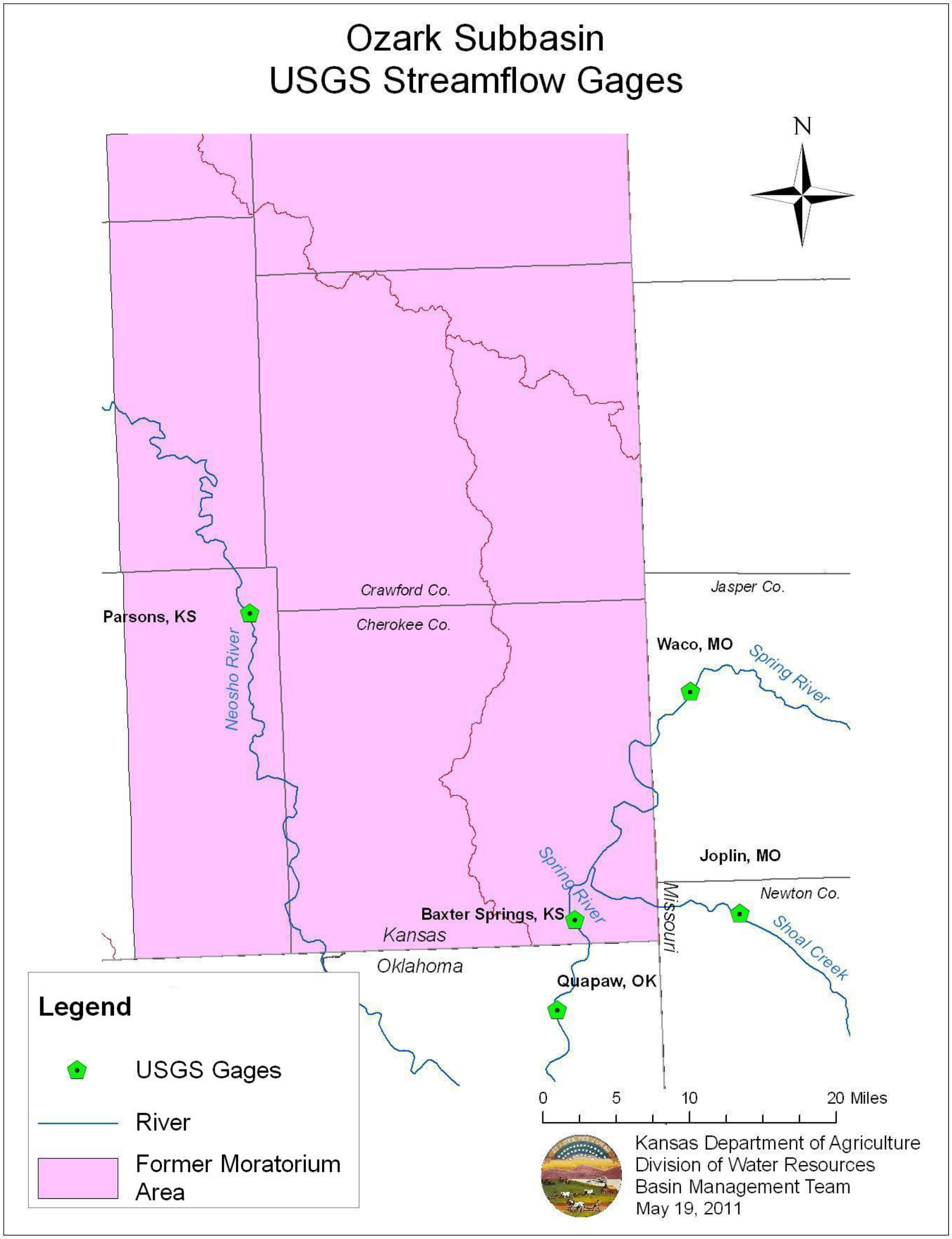


**Figure 5: Neosho River and Spring River USGS streamflow gages**

Figure 6 was derived from the Parsons, Kansas, Quapaw, Oklahoma, Joplin, Missouri, and Waco, Missouri USGS gages and demonstrates how flow can vary each year. The Baxter

Springs gage was installed in 2009, and will be included in subsequent reports. Following the 1951 flood the Neosho River reached periods of little to no flow during the subsequent drought. Preliminary flows in 2010 were down somewhat from 2009. Table 1 shows average annual streamflows for specific timeframes.

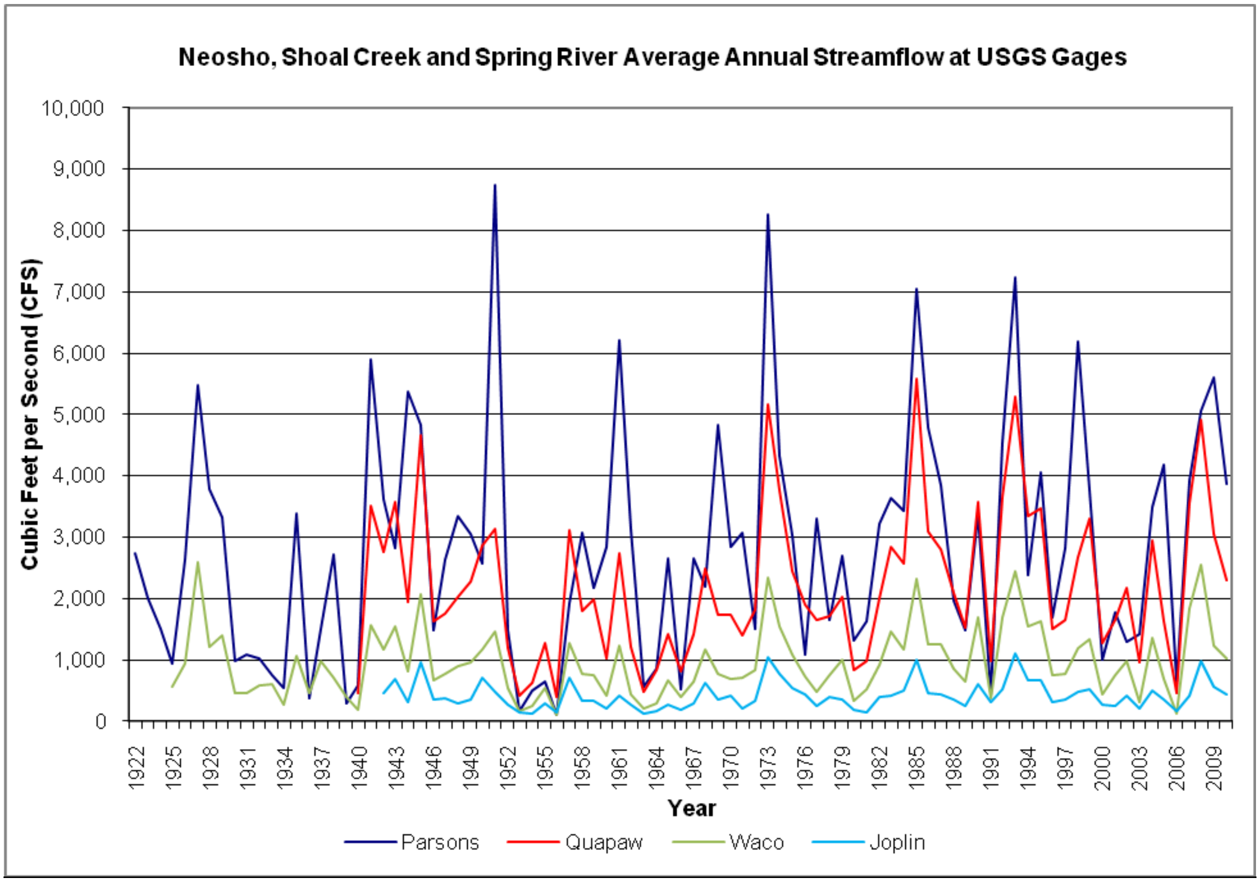


**Figure 6: Streamflow at USGS Gages 1921-2010**

**Table 1: Average Annual Streamflow**

| | **Average annual streamflow (cfs)** | | |
|---|---|---|---|
| **Gage (Period of Record)** | **Period of Record** | **1990-2000** | **2000-2009** |
| Parsons (1922 – present) | 2,793 cfs | 3,649 cfs | 2,844 cfs |
| Quapaw (1940 – present) | 2,224 cfs | 2,948 cfs | 2,264 cfs |
| Waco (1925 – present) | 957 cfs | 1,348 cfs | 1,025 cfs |
| Joplin (1942 – present) | 424 cfs | 551 cfs | 415 cfs |

In 1984, the Kansas legislature amended the Kansas Water Appropriation Act to establish Minimum Desirable Streamflows (MDS) on certain watercourses in Kansas. The statutory provision provided for the establishment of MDS flow criteria to be designated on a number of Kansas streams prior to a 1990 deadline. MDS flow criteria was established on the Neosho and Spring Rivers at specific USGS streamflow gages. Table 2 represents the MDS values for the lower Neosho River and the Spring River USGS streamflow gages.

Figure 7 shows the streamflow measurements for 2010, which were above respective MDS levels. The lower Neosho River gage is located near Parsons, Kansas and is used in administering MDS between the Iola, Kansas USGS gage and the Parsons, Kansas USGS gage. The Spring River gage near Quapaw, Oklahoma is used in administration of MDS at Baxter Springs, Kansas. The MDS values for the Neosho River near Parsons in parenthesis in Table 2 represent the spawning flows that are managed if the reservoir is in flood pool.

**Table 2: Minimal Desirable Streamflow (MDS)**

| River | Gage | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Neosho** | **Parsons** | 50 | 50 | 50 | 50 (100) | 50 (300) | 50 (300) | 50 | 50 | 50 | 50 | 50 | 50 |
| **Spring** | **Quapaw** | 175 | 200 | 250 | 300 | 450 | 350 | 200 | 160 | 120 | 120 | 150 | 175 |

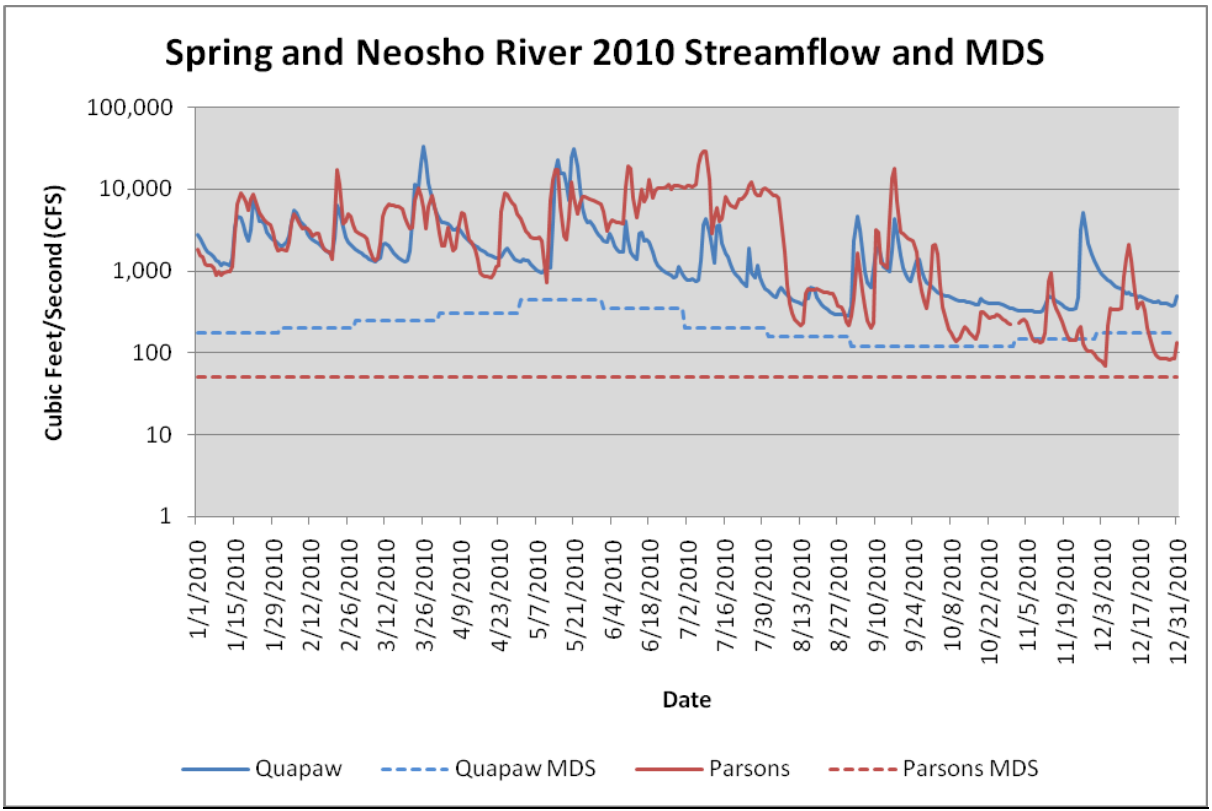


**Figure 7: Daily Streamflow and MDS for 2010**

Figure 8 charts the days in which MDS criteria are not met at the lower Neosho River gage and Spring River gage. Since the establishment of MDS in 1984, the frequency of streamflow below the MDS criteria has been less at the Quapaw gage than at the Parsons gage. This is partly due to the fact that streamflows on the lower Neosho River are affected by operations of three federal reservoirs located within the basin (Marion, Council Grove, and John Redmond Reservoirs). The lower Neosho has a greater potential for flows below MDS criteria for consecutive years, resulting in the administration of MDS on the Neosho River in 2002, 2003, 2006, and 2007. MDS administration occurred for the first time on the Spring River in 2006.

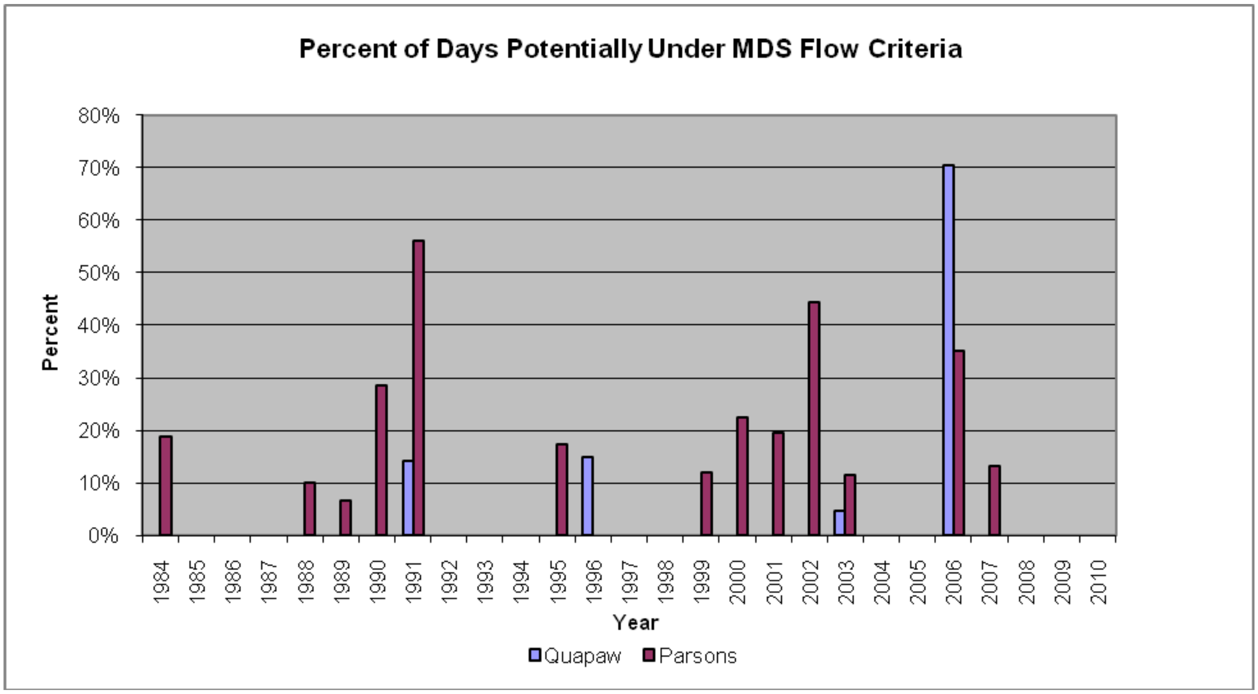


**Figure 8: Percent of days MDS is not met at USGS gages**

# IV. Groundwater

Monitoring wells used in this report are located in the Ozark aquifer and what we refer to as the Ozark Plateau aquifer (wells believed to be screened in both the Ozark and the Springfield Plateau aquifers). There are no known monitoring wells solely screened in the Springfield Plateau aquifer besides the dedicated observation well at Pittsburg, Kansas, which is charted in Figure 12. For this fieldwork summary, groundwater data was grouped by aquifer source. The monitoring well network is shown in Figure 9 and indicates which wells measure water quality, as discussed in section V. Water Quality, in addition to groundwater levels. Figure 10 through Figure 12 chart the groundwater levels in the Ozark and the Ozark Plateau aquifer. Well depths and water level trends vary between individual wells, which is partly due to the majority of the well network consisting of active municipal wells.

There is little historical water level data to compare to current water levels. The KDA-DWR measures a total of 27 wells in the Ozark Plateau region. Generally, winter (December, January and February) measurements are used for the Basin Management Team field analysis summary as this is a period in which irrigation wells are usually not pumping and recovery of the water table is occurring. Historically, in this area, spring, summer and fall were the common times to measure groundwater levels. Since the wells monitored in these subbasins are mostly municipal wells that pump year-round, capturing a period of recovery would be difficult. In reviewing the data, fall measurements (September, October, and November) seemed to be the most consistent time in which groundwater levels were taken; therefore, they were used for this analysis. The locations of the dedicated monitoring wells are shown in Figure 9. Legal descriptions and names for monitoring wells are available in the appendix.

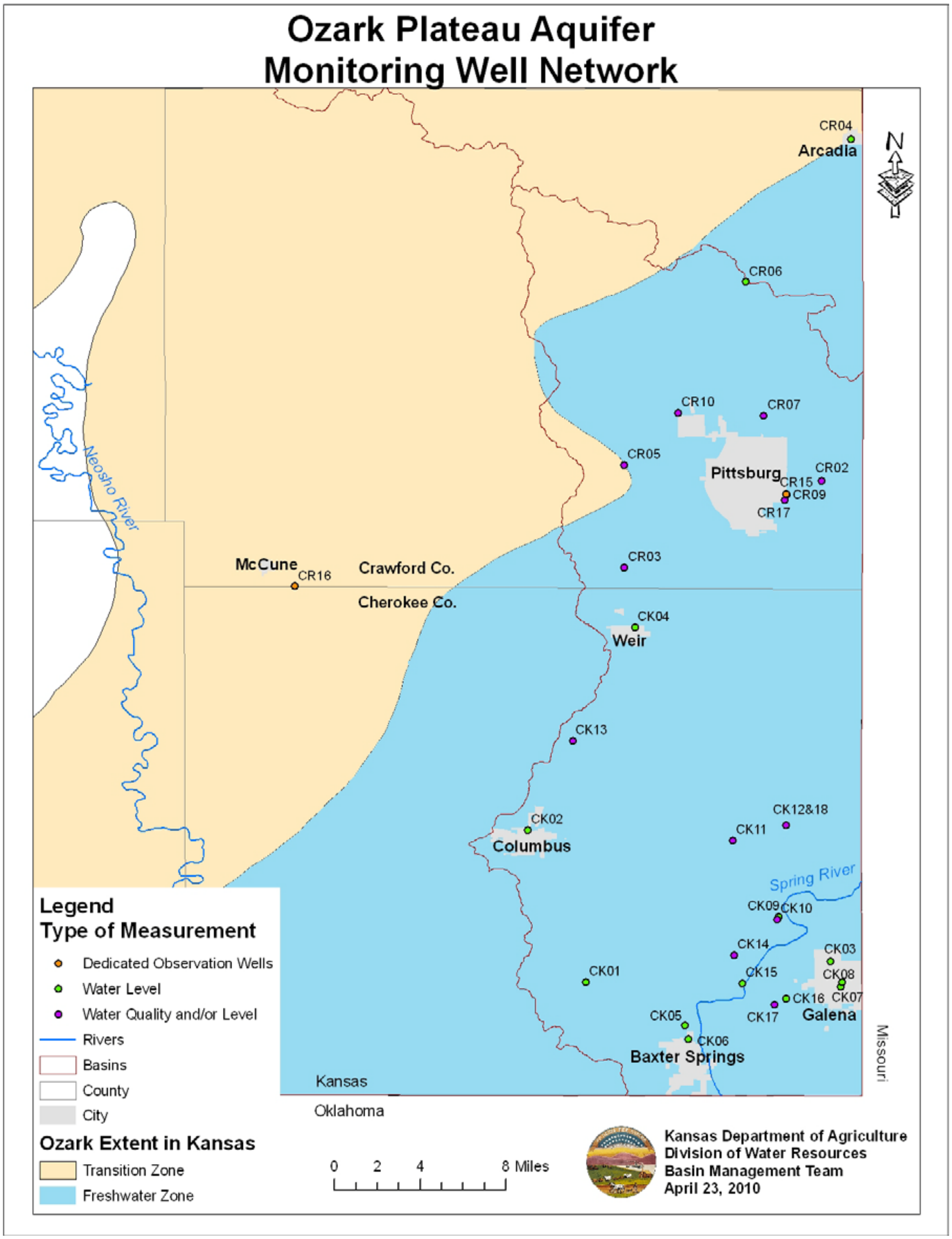


**Figure 9: Ozark Monitoring Wells**

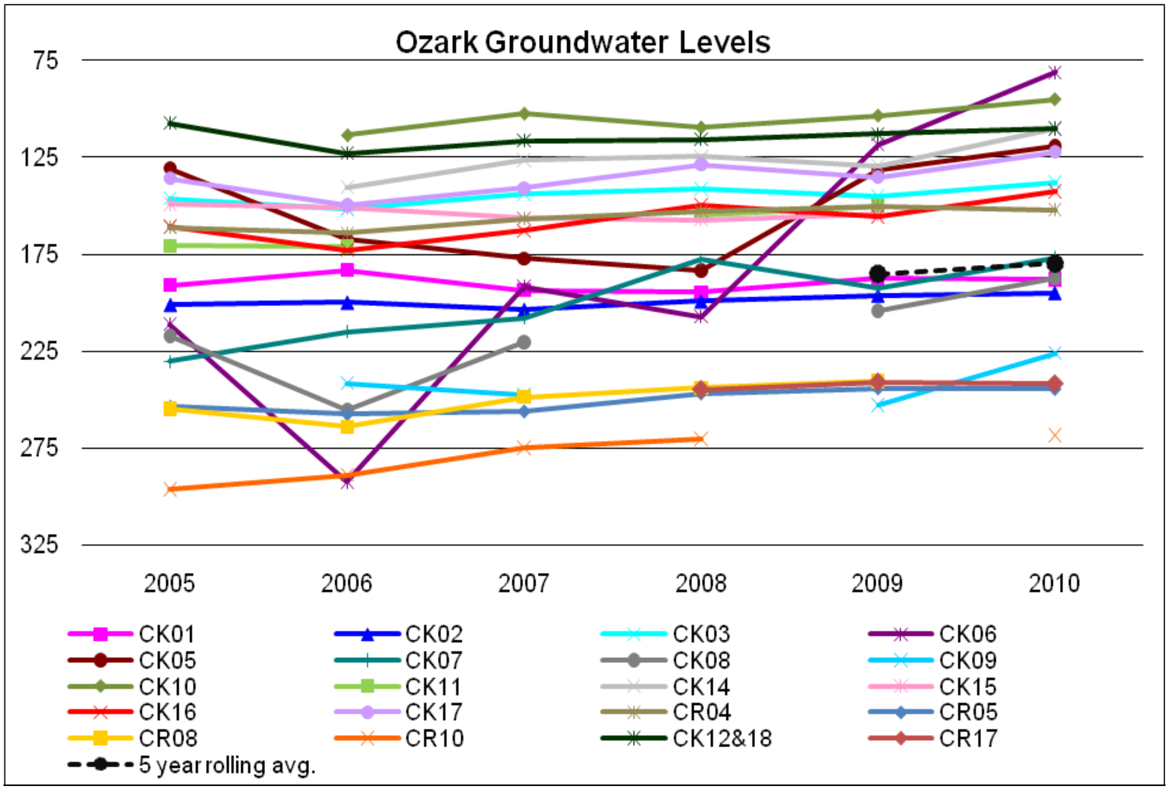


**Figure 10: Groundwater Levels in the Ozark Aquifer**

Figure 10 shows the monitoring wells located in the Ozark aquifer. Overall, the majority of well levels have increased by about 11 feet from 2009 to 2010. This ranges from a decrease of 1.62 feet in CR04 to an increase of 37.1 feet in CK06. Some of the recovery at CK05 and CK06 is attributed to a long period of non-use. CK05 has declined approximately 3.6 feet from 1988 to 2009 with yearly fluctuations sometimes as great as 100 feet. CK06 has had yearly fluctuations of up to 50 feet. CK12/CK18 has declined about 33 feet from 1975-2009. As a note, well CR17 has replaced CR08 in the network. Since these are pumping wells, some data is representative of pumping levels instead of static water levels.

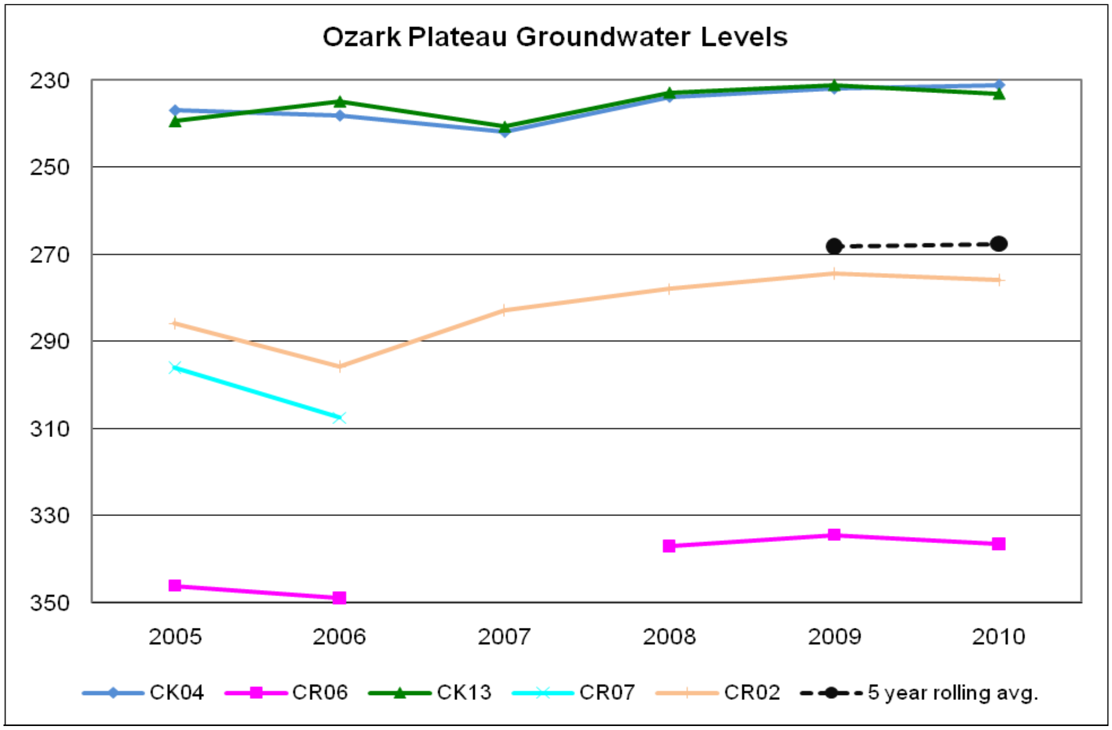


**Figure 11: Groundwater Levels in the Ozark Plateau aquifer**

In the Ozark Plateau aquifer, there are five monitoring wells (Figure 11). Overall, from 2005 to 2006 water levels declined by about 3 feet but increased nearly 11.5 feet from 2006 to 2009. From 2009 to 2010 the wells averaged a decline of 1.2 feet. CR07 has not been measured for the past four years due to sludge.

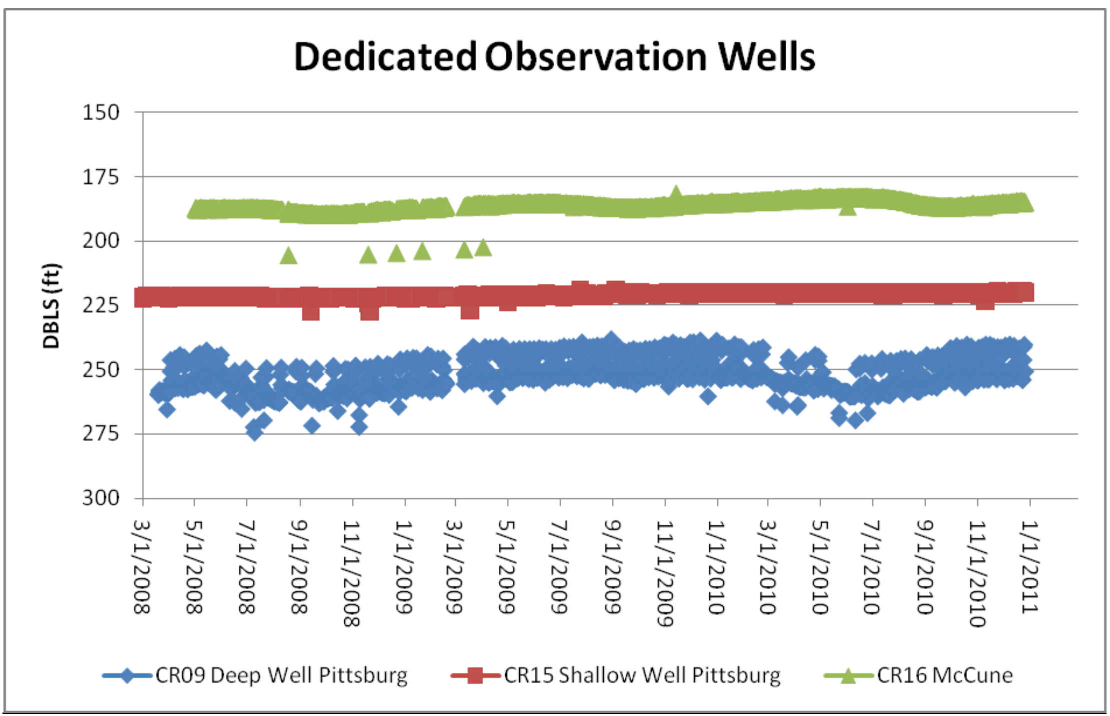


**Figure 12: Groundwater Levels from Dedicated Observation Wells**

Figure 12 shows the data from the three dedicated observation wells. CR09 and CR16 are measured in the Ozark aquifer, while CR15 is measured in the Springfield Plateau aquifer. Each well had a measurement recorded every 24 hours. Although the remote telemetry data system at the dedicated wells was discontinued, all the captured data will still be provided within future reports. The above graph shows daily measurements starting from March 2008 and ending by the beginning of 2011. CR09 shows the most significant daily fluctuations, with an overall increasing trend. CR15 and CR16 have remained relatively stable but also show a slight increasing trend since June 2008.

# V. Water Quality

Figure 13 to Figure 16 chart salinity and conductivity values in the Ozark aquifer and Ozark Plateau aquifer from March 2007 to November 2010. Figure 13 and Figure 14 show salinity levels have remained fairly consistent throughout the network. Figure 13 charts a range in salinity from 200 to 600 parts per million (ppm) in the Ozark aquifer, while the Ozark Plateau aquifer (Figure 14) has a range from 300 to 600 ppm. The U.S. Environmental Protection Agency's (EPA) secondary drinking water standard for chloride is 250 ppm. Since the salinity measurement includes all salts, it is not directly comparable to the safe drinking water chloride standard.

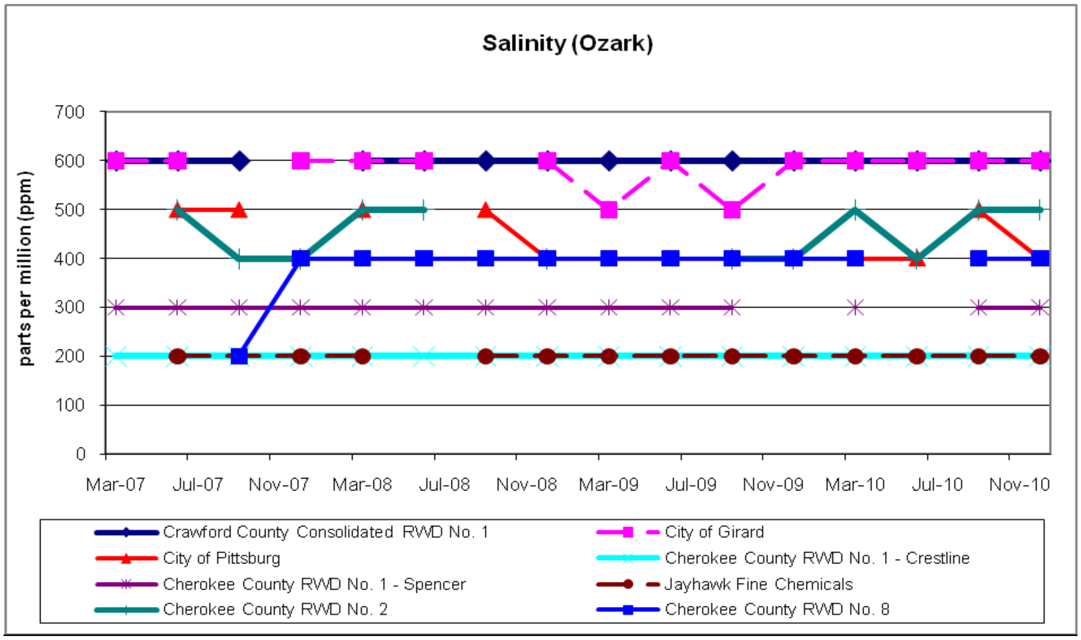


**Figure 13: Ozark Aquifer Salinity**

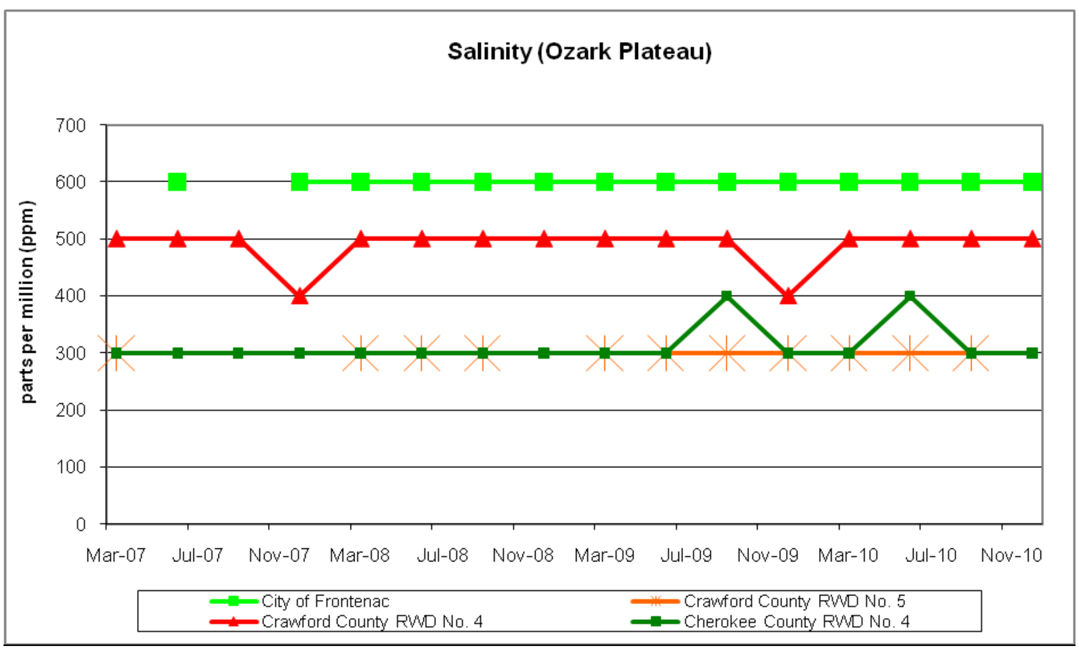


**Figure 14: Ozark Plateau Aquifer Salinity**

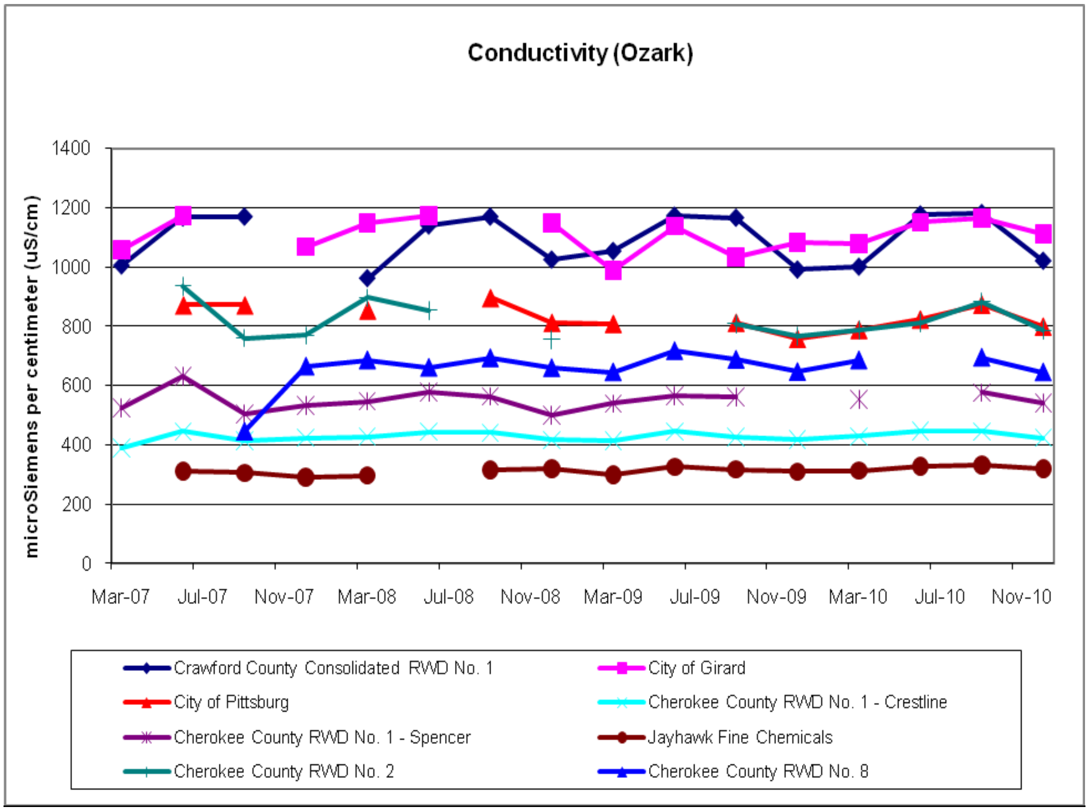


**Figure 15: Ozark Aquifer Conductivity**

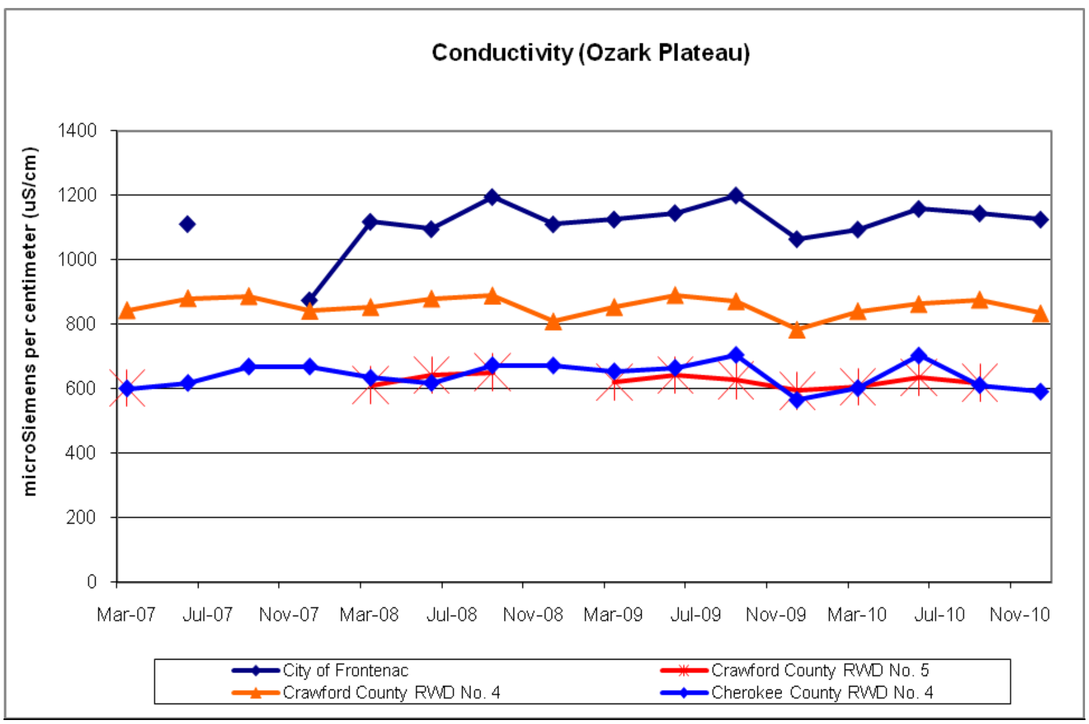


**Figure 16: Ozark Plateau Aquifer Conductivity**

Figure 15 and Figure 16 chart conductivity values for the Ozark aquifer and the Ozark Plateau aquifer. As with the salinity values, conductivity values remain fairly consistent with a range in the Ozark aquifer of 200 microsiemens/centimeter (µS/cm) to 1200 µS/cm (Figure 15) and a range in Ozark Plateau aquifer from 600 µS/cm to 1200 µS/cm (Figure 16). The electrical conductivity of water is directly related to the concentration of dissolved solids in the water. However, in order to determine the relationship laboratory tests are needed to correlate conductivity with total dissolved solids. The EPA secondary drinking water standard for total dissolved solids is 500 ppm; without knowing the correlation factor for these groundwater sources it is unknown at this time whether the range of conductivity measured in these aquifers is above or below the secondary drinking water standard. It is important to note that these samples were taken prior to any potential water treatment.

# VI. Water Use

The portion of the Neosho River basin and Spring River basin within the former Ozark Plateau moratorium region has a total of 238 water rights with an authorized quantity of 258,635 acre-feet. These water right numbers are for the following counties: Neosho, Crawford, Labette and Cherokee. The source of supply is groundwater for 106 water rights, or 45 percent of the total rights (Table 3). This analysis includes all water rights on record authorized for irrigation, municipal, recreation, industrial, domestic and stock water uses.

**Table 3: Water Rights in the Neosho and Spring River Subbasins[1]**

| Type | Source | Number of Rights | Authorized Quantity |
|---|---|---|---|
| Vested | Surface Water | 12 | 156,960 AF |
| Appropriated | Surface Water | 120 | 89,754 AF |
| Vested | Groundwater | 14 | 2,111 AF |
| Appropriated | Groundwater | 92 | 9,810 AF |
| **Total** | | **238** | **258,635 AF** |

The points of diversion associated with these water rights are shown in Figure 17. One water right may have multiple points of diversion. In the Neosho River basin, some municipal and industrial users obtain some of their water supply from federal reservoirs through Water Marketing Program contracts. Since Marketing Program contracts do not require water appropriation permits, diversions under contract are not reflected in Table 3. Additionally, all municipal and industrial users who divert surface water in the Neosho River basin are required to be members of the Cottonwood and Neosho River Basins Water Assurance District No. 3, which supports diversions of its members from a dedicated pool in Assurance reservoirs.

[1] The authorized acre-feet of usage for surface water include the amount of water that is diverted within the Spring River basin for industrial use by the Empire District Electric Company. Operations at the plant are largely flow-through cooling and a large portion of this water is discharged back into the Spring River. The Empire District Electric Company has three water rights; one of these rights is vested and the other two are appropriated. The total combined maximum authorized acre-feet for this company's rights totals to 177,794 acre-feet.

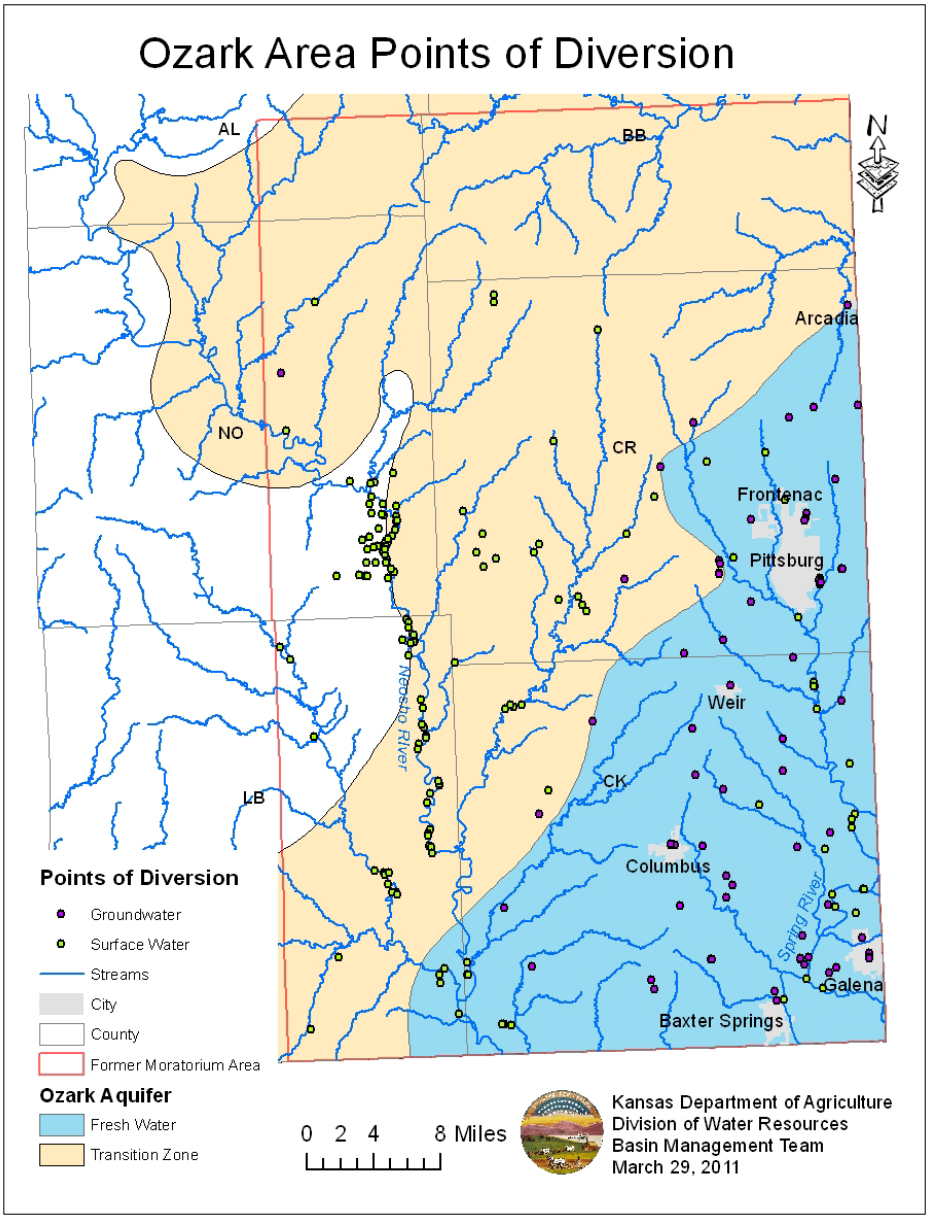


**Figure 17: Points of Diversion within the former Ozark Moratorium Area**

Water use in the former moratorium area tends to fluctuate per year largely due to varying surface water diversions within the Spring River basin used in cooling for the Empire District Electric Company. Usage ranges from 113,601 acre-feet in 2003 to 130,149 acre-feet in 1996. The total average groundwater and surface water use over the twenty-year span was 122,262 acre-feet (Figure 18). Groundwater usage averages 7,372 acre-feet per year from 1990-2009, which is at 62 percent of authorized quantities. Groundwater use in 2009 was about 6,170 acre-feet, which is below average. Average Spring River basin surface water use is 108,353 acre-feet, which is 48 percent of authorized quantities, whereas average Neosho River basin surface water use is 6,178 acre-feet, or 32 percent of authorized quantities.

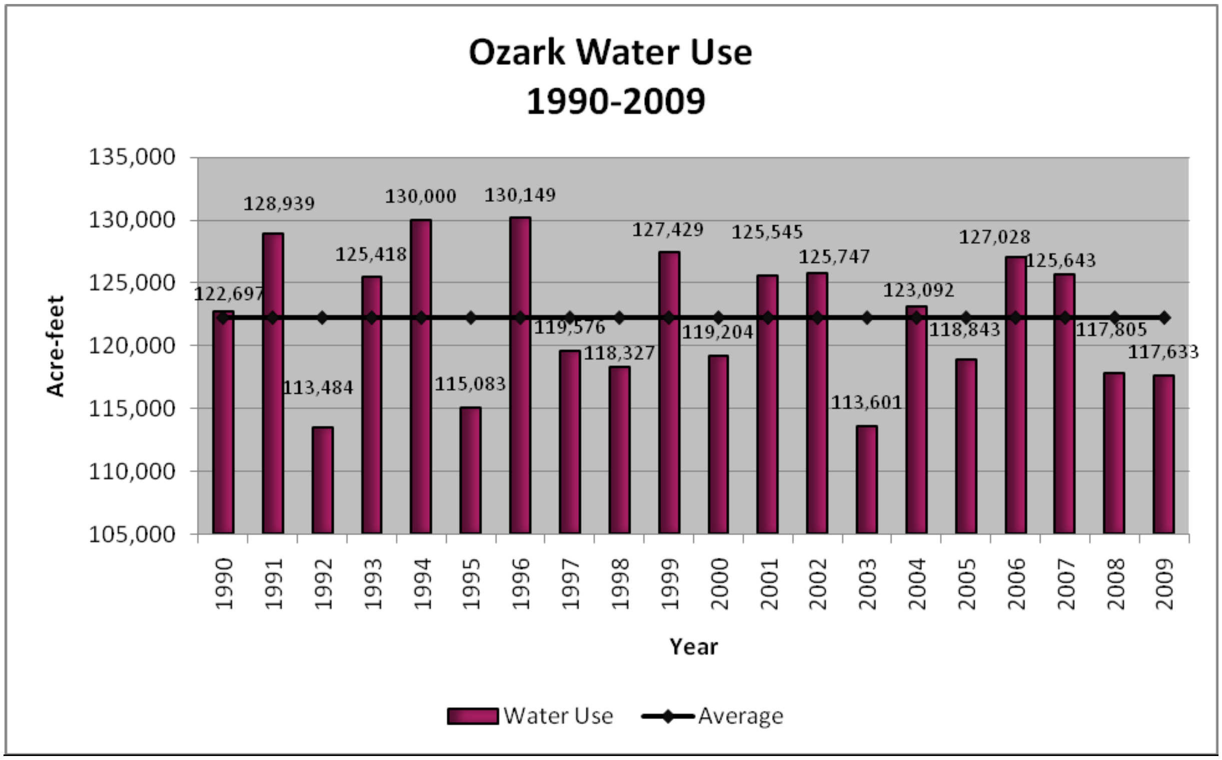


**Figure 18: Ground and Surface water use 1990-2009**

# VII. Conclusions

In conclusion, preliminary precipitation in the formerly regulated boundary area during 2010 was near average at 41.7 inches. Groundwater usage was 6,170 acre-feet in 2009, which is the lowest reported usage since 1990. Total surface water use was 111,464 acre-feet in 2009, which is below average. With above or near average precipitation in 2009 and 2010, streamflow levels have remained above MDS levels for 2010. Salinity and conductivity levels for both the Ozark aquifer and Ozark Plateau aquifer remained fairly consistent from March 2007 to November 2010.

In general, the Ozark aquifer water levels have increased from 2009 to 2010. The Ozark Plateau aquifer water levels had a slight decrease from 2009 to 2010. With the construction and release of the groundwater model, water quantity, recharge, and water movement in this aquifer system are better understood. It is important to continue to increase our understanding of the impacts of pumping, determine how fast the system recovers after recharge events, and identify other characteristics of the hydrologic system in order to evaluate the long-term effects of water usage in this subbasin, protect property rights, and ensure the benefits of these water resources to future generations.

# VIII. Appendix

| Name | Well ID | Aquifer | Legal | Level | Quality | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| Cherokee Co. RWD 2 | CK14 | Ozark | 34S25E08SWNWSW | Yes | Yes | 37.0930 | -94.7040 |
| Cherokee Co. RWD 9 | CK15 | Ozark | 34S25E20NWNENW | Yes | No | 37.0741 | -94.6983 |
| Cherokee Co. RWD 8 | CK16 | Ozark | 34S25E21NWNESE | Yes | No | 37.0640 | -94.6690 |
| Cherokee Co. RWD 8 | CK17 | Ozark | 34S25E28NWNWNW | Yes | Yes | 37.0600 | -94.6770 |
| Galena | CK07 | Ozark | 34S25E23SENENE | Yes | No | 37.0720 | -94.6320 |
| Galena | CK08 | Ozark | 34S25E13SWSWSW | Yes | No | 37.0750 | -94.6310 |
| Galena | CK03 | Ozark | 34S25E14NWNWNE | Yes | No | 37.0890 | -94.6390 |
| Baxter Springs | CK05 | Ozark | 34S24E36NENWNW | Yes | No | 37.0460 | -94.7370 |
| Baxter Springs | CK06 | Ozark | 34S24E36NWNWSW | Yes | No | 37.0370 | -94.7350 |
| Cherokee RWD 3 | CK01 | Ozark | 34S24E17SWSWSE | Yes | No | 37.0750 | -94.8040 |
| Jayhawk Fine Chemicals | CK09 | Ozark | 34S24E04NENWNE | Yes | No | 37.1190 | -94.6740 |
| Jayhawk Fine Chemicals | CK10 | Ozark | 34S25E04NENWNE | Yes | Yes | 37.1170 | -94.6750 |
| Cherokee RWD 1 | CK11 | Ozark | 33S25E18NENESE | Yes | Yes | 37.1700 | -94.7050 |
| Cherokee RWD 1 | CK12&18 | Ozark | 33S25E09SENESE | Yes | Yes | 37.1800 | -94.6690 |
| Columbus | CK02 | Ozark | 32S23E13NENENW | Yes | No | 37.1770 | -94.8430 |
| Cherokee Co. RWD 4 | CK13 | Ozark Plateau | 32S24E29NWNWNW | Yes | Yes | 37.2370 | -94.8130 |
| Weir | CK04 | Ozark Plateau | 31S24E27NWSESW | Yes | No | 37.3130 | -94.7710 |
| Arma | CR06 | Ozark Plateau | 29S25E05SESESW | Yes | No | 37.5446 | -94.6962 |
| Frontenac | CR07 | Ozark Plateau | 20S25E04NESWSW | Yes | Yes | 37.4550 | -94.6840 |
| Girard | CR05 | Ozark | 30S24E21NESENE | Yes | Yes | 37.4218 | -94.7784 |
| Arcadia | CR04 | Ozark | 28S25E01NESWNE | Yes | No | 37.6404 | -94.6250 |
| Crawford Co. RWD 1C | CR10 | Ozark | 30S24E02SESESE | Yes | Yes | 37.4568 | -94.7419 |
| Pittsburg | CR17 | Ozark | 30S25E28NESESE | Yes | Yes | 37.3980 | -94.6700 |
| Crawford Co. RWD 4 | CR03 | Ozark Plateau | 31S24E16NENENE | No | Yes | 37.3530 | -94.7780 |
| Crawford Co. RWD 5 | CR02 | Ozark Plateau | 30S25E23SESWSW | Yes | Yes | 37.4111 | -94.6449 |
| Pittsburg DWR | CR09 | Ozark | 30S25E28NENESE | Yes | No | 37.4021 | -94.6685 |
| McCune | CR16 | Ozark | 31S22E16SESESW | Yes | No | 37.3404 | -95.0004 |
| Pittsburg | CR15 | Springfield | 30S25E28SENESE | Yes | No | 37.4021 | -94.66876 |